Production-Scale Demonstration of Ammonium Perchlorate Bioreactor Technology

A Collaborative Effort between the US Air Force Research Laboratory (AFRL), the Joint Ordnance Commanders Group (JOCG), the Environmental Security Technology Certification Program (ESTCP), and Industry

THE PROBLEM:

Nearly every major weapon system that has solid propulsion, explosive devices, or pyrotechnic devices, contains perchlorate compounds. Ammonium perchlorate (AP) is the oxidizer and primary ingredient in solid propellant for most large rocket motors. High-pressure water washout is the accepted process to remove propellant for component or ingredient recovery, remanufacture, or demilitarization. The process produces large quantities of water contaminated with AP that must be treated as a hazardous waste. The Minuteman III propulsion remanufacture program will remove over 35 million pounds of propellant from 1200 first- and second-stage motors in order to recover and reuse the valuable motor cases.

The EPA and state regulators have established an action level of 18 ppb for perchlorate in ground/drinking water, which could further restrict discharge of AP wastewater and severely impact DOD propulsion programs. All major DOD propulsion contractors currently have AP disposal and/or groundwater contamination problems that could delay, add unnecessary costs, or otherwise jeopardize major production programs.

THE SOLUTION:

Air Force-sponsored research identified a bacterium, *Wolinella succinogenes*, designated "HAP-1," capable of degrading the perchlorate anion. The DoD community recognized the importance of the discovery and the Joint Ordnance Commanders Group (JOCG) provided funds for process development and pilot-scale demonstration of the biodegradation of AP-wastewater. The Air Force Research Laboratory, Materials and Manufacturing Directorate, Airbase and Environmental Technology Division (AFRL/MLQ) provided engineering oversight and program management. Applied Research Associates, Inc., an on-site contractor, provided operational-support.

ENGINEERING DEVELOPMENT:

Based upon bench-scale process development and process optimization, a pilot-scale system was designed around a 1300-liter anaerobic reactor capable of treating up to 4000 liters per day of dilute AP wastewater. Case Engineering, Lakeland, FL, designed and built the pilot system. The modular-designed, skid-mounted pilot system was delivered to Tyndall AFB, FL, in March 1995 and completely assembled in only one week (pilot-scale system pictured below).

Operation of the pilot system began in May 1995 and was operated continuously for over 2 months. It reduced perchlorate-contaminated wastewater, produced from water washout of a Minuteman Stage 2 rocket motor, from 3000 ppm to below detectable limits (0.5 ppm). A detailed economic analysis demonstrated that operating costs should be less than $0.20 per gallon for waste streams containing up to 6000 ppm AP.

IMPLEMENTATION:

Following pilot plant operation, further optimization studies were conducted at the bench to improve mixing, ascertain operational limitations, and establish engineering scaling factors for full-scale implementation. Through a Cooperative Research and Development Agreement (CRADA) with Thiokol Corp., and support from the JOCG and the Environmental Security Technology Certification Program (ESTCP) Office, the pilot system has been optimized, retrofitted, and integrated into Thiokol's production facility near Brigham City, UT. The integrated process is capable of treating perchlorate wastewater generated from production, maintenance, testing, remanufacturing, and demilitarization operations. Space Shuttle Solid Rocket Motor production and Minuteman III Propulsion Remanufacture programs will directly benefit from this very efficient and cost-effective biological treatment process.

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